Claims

1. An array of movable MEMS mirror devices having a high linear mirror fill factor, comprising:

a base structure; and

a plurality of selectively movable mirror structures, each being pivotally supported by a flexure connected to said base structure, and each mirror structure having a reflective surface portion,

the reflective surface portions of the mirror structures being arranged in close proximity to each other and in generally linear alignment forming a row structure, with the flexures supporting adjacent mirror structures being staggered on opposite sides of said row structure.

2. The array of Claim 1 wherein said array has a linear mirror fill factor of at least about 70%.

3. The array of Claim 1 wherein said array has a linear mirror fill factor of at least about 80%.

4. The array of Claim 1 wherein said array has a linear mirror fill factor of at least about 90%.

5. The array of Claim 1 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 70%.

6. The array of Claim 1 wherein each mirror structure is part of a

pixel, and each pixel has a linear mirror fill factor of at least about 80%.

7. The array of Claim 1 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 90%.

8. The array of Claim 1 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

9. The array of Claim 1 wherein spacing between adjacent reflective surface portions of said mirror structures is about up to 40 microns.

10. The array of Claim 1 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

11. The array of Claim 1 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5 microns.

12. The array of Claim 1 wherein each mirror structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said reflective surface portion, and wherein said flexure is connected to said neck member.

13. The array of Claim 1 wherein portions of said base structure are positioned on opposite sides of said row structure for supporting said flexures, wherein no portion of said base structure extends between the reflective surface portions of adjacent mirror structures.

14. The array of Claim 1 wherein at least two of said mirror structures

have different widths.

15. The array of Claim 1 wherein said flexures are folded.

16. The array of Claim 1 wherein said flexures have a generally non-rectangular cross-sectional shape.

17. The array of Claim 1 wherein said flexures have a generally U or V cross-sectional shape.

18. An optical switch having movable MEMS mirror devices with a high linear mirror fill factor, comprising:

a base structure;

a first mirror structure having a reflective surface portion, said first mirror structure pivotally supported by a first flexure connected to said base structure;

a second mirror structure having a reflective surface portion, said second mirror structure pivotally supported by a second flexure connected to said base structure;

the reflective surface portions of the first and second mirror structures being positioned in close proximity to each other, and said first and second flexures being on opposite sides of said reflective surface portions and generally in a plane of said reflective surface portions or a plane parallel thereto; and

means for selectively moving said first and second mirror structures about said first and second flexures, respectively.

19. The optical switch of Claim 18 wherein said base structure includes a portion for supporting said first flexure and a portion for supporting the second flexure, and wherein said portions of said base structure are on opposite sides of an area in which said reflective surface portions of said mirror structures are located.

20. The optical switch of Claim 19 wherein no portion of said base structure extends between said reflective surface portions of said mirror structures.

21. The optical switch of Claim 18 wherein said array has a linear mirror fill factor of at least about 70%.

22. The optical switch of Claim 18 wherein said array has a linear mirror fill factor of at least about 80%.

23. The optical switch of Claim 18 wherein said array has a linear mirror fill factor of at least about 90%.

24. The optical switch of Claim 18 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 70%.

25. The optical switch of Claim 18 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 80%.

26. The optical switch of Claim 18 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 90%.

27. The optical switch of Claim 18 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

28. The optical switch of Claim 18 wherein spacing between adjacent reflective surface portions of said mirror structures is about up to 40 microns.

29. The optical switch of Claim 18 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

30. The optical switch of Claim 18 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5 microns.

31. The optical switch of Claim 18 wherein each mirror structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said reflective surface portion, and wherein said flexure is connected to said neck member.

32. The optical switch of Claim 18 wherein said mirror structures have different widths.

33. The optical switch of Claim 18 wherein said flexures are folded.

34. The optical switch of Claim 18 wherein said flexures have a generally non-rectangular cross-sectional shape.

35. The optical switch of Claim 18 wherein said flexures have a generally U or V cross-sectional shape.

36. An array of MEMS mirror devices having a high linear mirror fill factor, comprising:

a base structure; and

a plurality of selectively movable mirror structures each comprising a first portion having a reflective surface thereon and a second portion having an actuation coil thereon, each mirror structure being pivotally supported by a flexure positioned between said first and second portions, said flexure being connected to said base portion;

wherein the first portions of said mirror structures are generally linearly aligned forming a row structure and arranged in close proximity, and wherein the second portions and flexures for adjacent mirror structures are staggered on alternating sides of said row structure.

37. The array of Claim 36 wherein said array has a linear mirror fill factor of at least about 70%.

38. The array of Claim 36 wherein said array has a linear mirror fill factor of at least about 80%.

39. The array of Claim 36 wherein said array has a linear mirror fill factor of at least about 90%.

40. The array of Claim 36 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 70%.

41. The array of Claim 36 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 80%.

42. The array of Claim 36 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 90%.

43. The array of Claim 36 wherein spacing between adjacent first portions of said mirror structures is about 20 microns.

44. The array of Claim 36 wherein spacing between adjacent first portions of said mirror structures is about up to 40 microns.

45. The array of Claim 36 wherein spacing between adjacent first portions of said mirror structures is about 5 to 10 microns.

46. The array of Claim 36 wherein spacing between adjacent first portions of said mirror structures is less than about 5 microns.

47. The array of Claim 36 wherein for each mirror structure, said first and second portions are enlarged and connected by a neck member, and wherein said flexure is connected to said neck member.

48. The array of Claim 36 wherein said base structure comprises support members on opposite sides of said row structure for supporting said flexures, wherein said support members do not extend between adjacent first

portions of said mirror structures.

49. The array of Claim 36 wherein at least two of said mirror structures have different widths.

50. The array of Claim 36 wherein said flexures are folded.

51. The array of Claim 36 wherein said flexures have a generally non-rectangular cross-sectional shape.

52. The array of Claim 36 wherein said flexures have a generally U or V cross-sectional shape.

53. An array of movable MEMS mirror devices comprising:

a base structure; and

a plurality of selectively movable mirror structures, each being pivotally supported by a flexure connected to said base structure, and each having a reflective surface portion, wherein said reflective surface portions are generally linearly aligned and arranged in close proximity with a linear mirror fill factor of at least about 70%.

54. The array of Claim 53 wherein the linear fill factor is at least about 80%.

55. The array of Claim 53 wherein the linear fill factor is at least about 90%.

56. The array of Claim 53 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

57. The array of Claim 53 wherein spacing between adjacent reflective surface portions of said mirror structures is about up to 40 microns.

58. The array of Claim 53 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

59. The array of Claim 53 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5 microns.

60. The array of Claim 53 wherein each mirror structure comprises first and second enlarged portions connected by a neck member, wherein first enlarged portions has said reflective surface portion, and said flexure is connected to said neck member.

61. The array of Claim 53 wherein said base structure comprises support members on opposite sides of said linearly aligned reflective surface portions for supporting said flexures, wherein no portion of said support members extends between said reflective surface portions of said mirror structures.

62. The array of Claim 53 wherein at least two of said mirror structures have different widths.

63. The array of Claim 53 wherein said flexures are folded.

64. The array of Claim 53 wherein said flexures have a generally non-rectangular cross-sectional shape.

65. The array of Claim 53 wherein said flexures have a generally U or V cross-sectional shape.

66. An array of movable MEMS mirror devices, comprising:

a base structure;

a plurality of selectively movable mirror structures, each including a reflective surface portion; and

means for pivotally supporting said mirror structures such that the reflective surface portions of the mirror structures are generally linearly aligned and positioned in sufficiently close proximity such that the array has a linear mirror fill factor of at least about 70%.

67. The array of Claim 66 wherein the linear mirror fill factor is at least about 80%.

68. The array of Claim 66 wherein the linear mirror fill factor is at least about 90%.

69. The array of Claim 66 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

70. The array of Claim 66 wherein spacing between adjacent reflective

surface portions of said mirror structures is about up to 40 microns.

71. The array of Claim 66 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

72. The array of Claim 66 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5.

73. The array of Claim 66 wherein each mirror structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said reflective surface portion.

74. The array of Claim 66 wherein at least two of said mirror structures have different widths.

75. The array of Claim 66 wherein said mirror structures are supported on folded flexures.

76. The array of Claim 66 wherein said mirror structures are supported on flexures having a generally non-rectangular cross-sectional shape.

77. The array of Claim 66 wherein said mirror structures are supported on flexures having a generally U or V cross-sectional shape.

78. A method of selectively switching optical signals between input and output optical fibers, comprising:

providing an optical switch having an array of selectively movable

MEMS mirror devices, each having a reflective surface portion, the reflective surface portions of the mirror devices being generally linearly aligned and arranged in close proximity to each other such that the array has a linear mirror fill factor of at least about 70%; and

selectively actuating mirror devices to deflect optical signals from input fibers to desired output fibers.

79. The method of Claim 78 wherein the linear mirror fill factor is at least about 80%.

80. The method of Claim 78 wherein the linear mirror fill factor is at least about 90%.

81. The method of Claim 78 wherein said mirror devices are pivotally mounted on flexures, and wherein selectively actuating mirror devices comprises selectively tilting the mirror devices about the flexures.

82. An array of movable MEMS devices having a high linear mirror fill factor, comprising:

a base structure; and

a plurality of selectively movable structures, each being pivotally supported by a flexure connected to said base structure, and each structure having an exposed surface portion,

the exposed surface portions of the structures being arranged in

close proximity to each other and in generally linear alignment forming a row structure, with the flexures supporting adjacent structures being staggered on opposite sides of said row structure.

83. The array of Claim 82 wherein said array has a linear exposed surface fill factor of at least about 70%.

84. The array of Claim 82 wherein said array has a linear exposed surface fill factor of at least about 80%.

85. The array of Claim 82 wherein said array has a linear exposed surface fill factor of at least about 90%.

86. The array of Claim 82 wherein each movable structure is part of a pixel, and each pixel has a linear exposed surface fill factor of at least about 70%.

87. The array of Claim 82 wherein each movable structure is part of a pixel, and each pixel has a linear exposed surface fill factor of at least about 80%.

88. The array of Claim 82 wherein each movable structure is part of a pixel, and each pixel has a linear exposed surface fill factor of at least about 90%.

89. The array of Claim 82 wherein spacing between adjacent exposed surface portions of said structures is about 20 microns.

90. The array of Claim 82 wherein spacing between adjacent exposed surface portions of said structures is about up to 40 microns.

91. The array of Claim 82 wherein spacing between adjacent exposed surface portions of said structures is about 5 to 10 microns.

92. The array of Claim 82 wherein spacing between adjacent exposed surface portions of said structures is less than about 5 microns.

93. The array of Claim 82 wherein each structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said exposed surface portion, and wherein said flexure is connected to said neck member.

94. The array of Claim 82 wherein portions of said base structure are positioned on opposite sides of said row structure for supporting said flexures, wherein no portion of said base structure extends between the exposed surface portions of adjacent structures.

95. The array of Claim 82 wherein at least two of said structures have different widths.

96. The array of Claim 82 wherein said flexures are folded.

97. The array of Claim 82 wherein said flexures have a generally non-rectangular cross-sectional shape.

98. The array of Claim 82 wherein said flexures have a generally U or V cross-sectional shape.

99. The array of Claim 82 wherein said exposed surface portions

comprise reflective surface portions.

100. An array of movable MEMS mirror devices having a high linear mirror fill factor, comprising a plurality of selectively movable mirror structures, each mirror structure being pivotally supported by a flexure and having a reflective surface portion, the reflective surface portions of the mirror structures being arranged in close proximity to each other and in generally linear alignment forming a row structure, with the flexures supporting adjacent mirror structures being staggered on opposite sides of said row structure.

101. The array of Claim 100 wherein said array has a linear mirror fill factor of at least about 70%.

102. The array of Claim 100 wherein said array has a linear mirror fill factor of at least about 80%.

103. The array of Claim 100 wherein said array has a linear mirror fill factor of at least about 90%.

104. The array of Claim 100 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 70%.

105. The array of Claim 100 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 80%.

106. The array of Claim 100 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 90%.

107. The array of Claim 100 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

108. The array of Claim 100 wherein spacing between adjacent reflective surface portions of said mirror structures is about up to 40 microns.

109. The array of Claim 100 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

110. The array of Claim 100 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5 microns.

111. The array of Claim 100 wherein each mirror structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said reflective surface portion, and wherein said flexure is connected to said neck member.

112. The array of Claim 100 wherein said flexures are connected to a base structure, and wherein portions of said base structure are positioned on opposite sides of said row structure for supporting said flexures, wherein no portion of said base structure extends between the reflective surface portions of adjacent mirror structures.

113. The array of Claim 100 wherein at least two of said mirror structures have different widths.

114. The array of Claim 100 wherein said flexures are folded.

115. The array of Claim 100 wherein said flexures have a generally non-rectangular cross-sectional shape.

116. The array of Claim 100 wherein said flexures have a generally U or V cross-sectional shape.

117. A method of selectively switching optical signals between input and output optical fibers, comprising:

providing an optical switch having an array of selectively movable MEMS mirror devices comprising a base structure and a plurality of selectively movable mirror structures, each mirror structure being pivotally supported by a flexure connected to said base structure, and each mirror structure having a reflective surface portion, the reflective surface portions of the mirror structures being arranged in close proximity to each other and in generally linear alignment forming a row structure, with the flexures supporting adjacent mirror structures being staggered on opposite sides of said row structure; and

selectively actuating mirror devices to deflect optical signals from input fibers to desired output fibers.

118. The method of Claim 117 wherein said array has a linear mirror fill factor of at least about 70%.

119. The method of Claim 117 wherein said array has a linear mirror fill factor of at least about 80%.

120. The method of Claim 117 wherein said array has a linear mirror fill factor of at least about 90%.

121. The method of Claim 117 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 70%.

122. The method of Claim 117 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 80%.

123. The method of Claim 117 wherein each mirror structure is part of a pixel, and each pixel has a linear mirror fill factor of at least about 90%.

124. The method of Claim 117 wherein spacing between adjacent reflective surface portions of said mirror structures is about 20 microns.

125. The method of Claim 117 wherein spacing between adjacent reflective surface portions of said mirror structures is about up to 40 microns.

126. The method of Claim 117 wherein spacing between adjacent reflective surface portions of said mirror structures is about 5 to 10 microns.

127. The method of Claim 117 wherein spacing between adjacent reflective surface portions of said mirror structures is less than about 5 microns.

128. The method of Claim 117 wherein each mirror structure comprises two enlarged portions connected by a neck member, wherein one of said two enlarged portions includes said reflective surface portion, and wherein said flexure is connected to said neck member.

129. The method of Claim 117 wherein portions of said base structure are positioned on opposite sides of said row structure for supporting said

flexures, wherein no portion of said base structure extends between the reflective surface portions of adjacent mirror structures.

130. The method of Claim 117 wherein at least two of said mirror structures have different widths.

131. The method of Claim 117 wherein said flexures are folded.

132. The method of Claim 117 wherein said flexures have a generally non-rectangular cross-sectional shape.

133. The method of Claim 117 wherein said flexures have a generally U or V cross-sectional shape.

134. The method of Claim 117 wherein selectively actuating mirror devices comprises selectively tilting mirror structures about respective flexures.